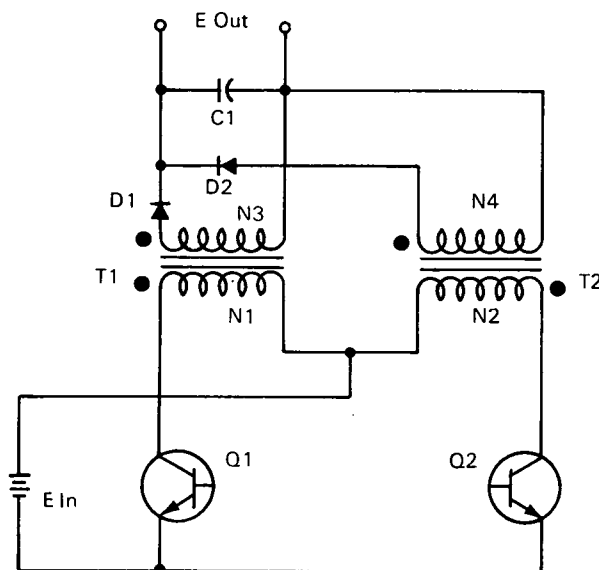


NASA TECH BRIEF



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Full Wave Dc-To-Dc Converter Using Energy Storage Transformers



The problem:

Engines for electric propulsion present a number of power-conditioning problems. Reductions in weight and increases in efficiency of the power converter for an ion thruster are vital requirements. Since relatively high power levels are involved, the weight of the power-conditioning system may be substantial.

Another prime problem is providing compatibility with the transient loading characteristics of these ion thrusters.

The solution:

A full-wave dc-to-dc converter using energy storage transformers to provide a method of dc-to-dc conversion and regulation. The converter has a high degree of physical simplicity, is lightweight (1.9 pounds) and has high efficiency (87%).

How it's done:

The figure shows the basic circuit for a full-wave converter using the energy-storage-transformer principle. Transistors Q1 and Q2 are the power transistors; diodes D1 and D2 are the output rectifiers. Cores T1 and T2 have a linear flux-versus-mmf (magnetomotive force) characteristic such as can be obtained by the introduction of a small airgap into the magnetic path. Capacitor C1 is used as a filter capacitor to provide a low-ripple direct voltage output.

In order to accomplish voltage conversion and regulation the circuit functions as follows. By means of a drive circuit (not included in the figure) transistors Q1 and Q2 are cyclically turned on and off. Assume, for example, that Q1 has just been turned on after having ended its cyclic period of off time. The voltage E_{in} is impressed across winding N1 of transformer T1

(continued overleaf)

with the undotted end of this winding being made positive. A voltage will simultaneously be induced in winding N3 so that its undotted end becomes positive. Contrary to the operation of conventional converters, however, a current will flow in the primary winding N1 of transformer T1 during this interval, whereas no current will flow in the secondary winding N3. Diode D1 in series with N3 will be reverse biased. Thus, during the time that Q1 conducts, the current in winding N1 increases and inductive energy is stored in this "energy-storage transformer." During this interval, the transformer provides no output current to the filter capacitor and load.

When transistor Q1 turns off, the current in winding N1 is abruptly interrupted. The mmf existing on core T1 cannot, however, change instantly (this would imply infinite voltages on windings N1 and N3.) Therefore, when the current in N1 is interrupted, the direction of flux change in T1 will reverse and a proportional current will immediately begin to flow in N3, and thus to the filter capacitor and load. That is, when T1 stores energy during the "on" time of Q1, it releases this energy to the filter capacitor and load during the "off" time of Q1. By cyclically turning transistor Q1 on and off, this left half of the circuit may be made to perform as a dc-to-dc converter.

Transistor Q1, T1 and its windings, and D1 form one half of the full-wave converter. Transistor Q2, T2 and its windings, and D2 form the other half. Each half

could be used independently for voltage conversion, but the use of both halves together, operated 180 degrees out of phase, has important advantages insofar as input and output ripple currents are concerned. Since the magnitude of these ripple currents affects efficiency and the necessary size and weight of filter components, the use of the full-wave configuration has significant advantages.

The light weight, high efficiency, and physical simplicity resulting from the use of these circuit techniques indicate that this type of circuitry should also have advantages in more general applications.

Notes:

1. No further documentation is available.
2. Technical questions may be directed to:
Technology Utilization Officer
Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135
Reference: B69-10140

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

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